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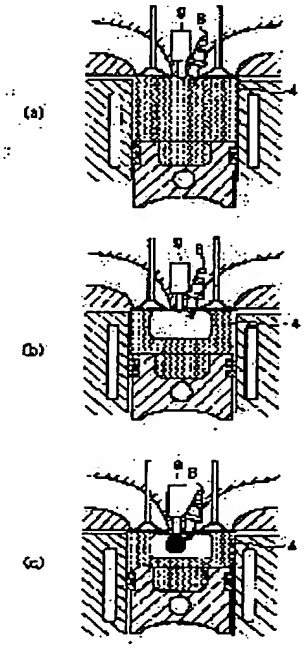
## (54) COMPRESSED SELF-IGNITION INTERNAL COMBUSTION ENGINE

(57)Abstract:

PROBLEM TO BE SOLVED: To stably control ignition timing and suppress NOx producing amount not more than a certain value by optimizing air-fuel mixture distribution in a cylinder for compressed self-ignition combustion.

SOLUTION: Using an air-fuel mixture injection valve 9, first air-fuel mixture injection is performed in an intake stroke to form a dilute air-fuel mixture layer in a combustion engine 4. Then, only air is injected in a compressing stroke to form an air layer having no flame propagation. Subsequently, second air-fuel mixture injection is performed to form a high-concentration air-fuel mixture layer under high back pressure, and the layer is ignited by spark by an ignition plug 10. The dilute air-fuel mixture layer is ignited by itself due to increase of pressure and temperature by the spark ignition combustion.

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CLAIMS

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[Claim(s)]
[Claim 1] the compressed self-ignition type internal combustion engine which the injection valve which injects a direct fuel is provided [ internal combustion engine ] and makes compressed self-ignition combustion perform in a predetermined service condition at least in a cylinder -- setting -- the inside of a cylinder -- gaseous mixture -- a place -- an enriched-mixture field and thin gaseous mixture -- the compressed self-ignition type internal combustion engine characterized by making it the layer which divides into a field and does not carry out flame propagation of between an enriched mixture and thin gaseous mixture.
[Claim 2] The compressed self-ignition type internal combustion engine according to claim 1 characterized by having allotted the enriched mixture centering on the inside of a cylinder, having allotted gaseous mixture thin like it does not carry out flame propagation so that the surroundings of it might be surrounded, and allotting the thin gaseous mixture which results in self-ignition when said enriched mixture burns around it.
[Claim 3] The compressed self-ignition type internal combustion engine according to claim 1 characterized by separating in the layer which allots an enriched mixture to the location which carried out eccentricity from the center of the inside of a cylinder, allots the thin gaseous mixture which results in self-ignition when an enriched mixture burns in the location at which this enriched mixture is not crossed, and does not carry out flame propagation of said enriched mixture and said thin gaseous mixture.
[Claim 4] The compressed self-ignition type internal combustion engine of any one publication of claim 1 characterized by dividing fuel injection into 2 times, performing it using the injection valve which can inject a direct fuel and air in a cylinder, and injecting only air between the 1st fuel injection and the 2nd fuel injection - claim 3.
[Claim 5] The compressed self-ignition type internal combustion engine of any one publication of claim 1 characterized by providing the accessory cell which carries out opening to a combustion chamber, dividing fuel injection into 2 times, performing it using the injection valve which can inject a direct fuel and air to this accessory cell, and injecting only air between the 1st fuel injection and the 2nd fuel injection - claim 3.
[Claim 6] The compressed self-ignition type internal combustion engine of any one publication of claim 1 characterized by giving two or more nozzle holes which inject a fuel, respectively in cylinder shaft orientations and the direction to which it points to the boa wall at the time near the top dead center while preparing said injection valve in the center of cylinder head abbreviation - claim 3.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the compressed self-ignition type internal combustion engine which makes compressed self-ignition combustion perform in a predetermined service condition at least.
[0002]
[Description of the Prior Art] There are some which are indicated by JP,10-196424,A as a compressed self-ignition type internal combustion engine's example. To the gaseous mixture compressed until it has the control piston as an auxiliary compression means apart from the piston in a cylinder and resulted in the elevated temperature in front of self-ignition, this is applying compression by the control piston further, and has composition to which self-ignition of the gaseous mixture is carried out all at once.
[0003] Moreover, the compressed self-ignition type internal combustion engine having an ignition plug is indicated by JP,11-210539,A. the gas temperature in the cylinder in the compression stroke last stage lights this -- gaseous mixture -- by judging whether it is the target temperature which causes the whole self-ignition, and controlling the valve-opening stage of an inlet valve, it is controlling so that the gas temperature in the cylinder in the compression stroke last stage is maintained by target temperature.
[0004]
[Problem(s) to be Solved by the Invention] Although each of two above-mentioned conventional techniques tends to control the ignition stage of self-ignition combustion compulsorily, engine structure becomes complicated too much and the technique of JP,10-196424,A using a control piston is difficult to put in practical use. The width of face of the auxiliary pressure buildup which can be given by jump spark ignition with the technique of JP,11-210539,A using jump spark ignition on the other hand is small, and it is difficult to perform stable ignition stage control.
[0005] Although it is possible to carry out the flame-propagation combustion of the fuel of the field which formed in a part of combustion chamber the field where fuel concentration is high, and was restricted to the gaseous mixture of this field by carrying out jump spark ignition as an approach of enlarging pressure-buildup width of face by jump spark ignition, if the situation of a combustion chamber changes variously, the range of the field which carries out flame-propagation combustion also changes variously, and it will become difficult to control the amount of NOx which generates with flame-propagation combustion of generation below to a constant rate.
[0006] then, this invention -- gaseous mixture -- place formation -- paying one's attention -- the gaseous mixture in a cylinder -- while enabling control of the ignition stage stabilized by optimizing distribution for a compressed self-ignition type internal combustion engine, it aims at controlling the amount of NOx generation below to constant value.
[0007]
[Means for Solving the Problem] for this reason, the compressed self-ignition type internal combustion engine which the injection valve which injects a direct fuel is provided [ internal combustion engine ] and makes compressed self-ignition combustion perform by the predetermined service condition at least in a cylinder in invention of claim 1 -- setting -- the inside of a cylinder -- gaseous mixture -- a place -- an enriched-mixture field and thin gaseous mixture -- it divides into a

field and is characterized by making it the layer which does not carry out flame propagation of between an enriched mixture and thin gaseous mixture.
[0008] In invention of claim 2, it is characterized by having allotted the enriched mixture centering on the inside of a cylinder, having allotted gaseous mixture thin like it does not carry out flame propagation so that the surroundings of it might be surrounded, and allotting the thin gaseous mixture which results in self-ignition when said enriched mixture burns around it. In invention of claim 3, an enriched mixture is allotted to the location which carried out eccentricity from the center of the inside of a cylinder, the thin gaseous mixture which results in self-ignition when an enriched mixture burns in the location at which this enriched mixture is not crossed is allotted, and it is characterized by separating in the layer which does not carry out flame propagation of said enriched mixture and said thin gaseous mixture.
[0009] In invention of claim 4, using the injection valve which can inject a direct fuel and air in a cylinder, fuel injection is divided into 2 times, and is performed, and it is characterized by injecting only air between the 1st fuel injection and the 2nd fuel injection. In invention of claim 5, the accessory cell which carries out opening to a combustion chamber is provided, using the injection valve which can inject a direct fuel and air to this accessory cell, fuel injection is divided into 2 times, and is performed, and it is characterized by injecting only air between the 1st fuel injection and the 2nd fuel injection.
[0010] In invention of claim 6, while preparing said injection valve in the center of cylinder head abbreviation, it is characterized by giving two or more nozzle holes which inject a fuel, respectively in cylinder shaft orientations and the direction to which it points to the boa wall at the time near the top dead center.
[0011]
[Effect of the Invention] according to invention of claim 1 -- the inside of a cylinder -- gaseous mixture -- a place -- an enriched-mixture field and thin gaseous mixture -- a field -- two-layer --- izing -- an enriched-mixture layer and thin gaseous mixture -- by separating a layer in the layer which does not carry out flame propagation In order that the flame by jump spark ignition of an enriched-mixture layer may not spread to a thin mixed gaseous layer but a thin mixed gaseous layer may carry out self-ignition by the rise of the pressure by combustion of an enriched-mixture layer, and temperature, While a self-ignition stage is certainly controllable by controlling a jump-spark-ignition stage, it can prevent certainly that the amount of the fuel contributed to flame propagation combustion turns into more than the amount of setup, and generation of NOx can be controlled.
[0012] in order to become possible to control steep combustion by according to invention of claim 2 allotting an enriched mixture centering on the inside of a cylinder, and allotting the thin gaseous mixture which carries out self-ignition to the outside field where temperature is comparatively low from the core in a cylinder, and to become possible to extend a compressed-self-ignition combustion zone to a heavy load side and also to burn an enriched mixture centering on the inside of a cylinder -- unburnt -- gaseous mixture controls and it becomes possible to reduce HC discharge.
[0013] By generating heat in the location as for which the enriched mixture carried out eccentricity from the core in a cylinder by allotting an enriched mixture to the location which carried out eccentricity from the center of the inside of a cylinder according to invention of claim 3, whenever [ cylinder internal temperature ], it becomes possible to control steep combustion because spots arise in distribution, and it becomes possible to extend a compressed self-ignition combustion zone to a heavy load side. By according to invention of claim 4, dividing fuel injection into 2 times, performing it using the injection valve which can inject a direct fuel and air in a cylinder, and injecting only air between the 1st fuel injection and the 2nd fuel injection The fuel by the 1st fuel injection is mixed with the air of a combustion chamber, and is diluted, the field of only air is formed of a subsequent air injection, and high concentration gaseous mixture is formed under high back pressure of the 2nd fuel injection performed continuously. The stable self-ignition combustion is realizable, controlling [ by this, can separate certainly so that flame propagation of the enriched mixture for jump spark ignition and the thin gaseous mixture for self-ignition may not be carried out by the air space, and ] NOx.
[0014] According to invention of claim 5, provide the accessory cell which is open for free passage to a combustion chamber, and the injection valve which can inject a direct fuel and air is used for

this accessory cell. By dividing fuel injection into 2 times, performing it, and injecting only air between the 1st fuel injection and the 2nd fuel injection A subsequent air injection can scavenge the fuel by the 1st fuel injection certainly from an accessory cell, it can be mixed with the air of a combustion chamber, and can be diluted, and the fuel by the 2nd fuel injection can form an enriched mixture in an accessory cell because the air injected before that plugs up accessory cell opening. By this, it can separate certainly so that flame propagation of the enriched mixture for jump spark ignition and the thin gaseous mixture for self-ignition may not be carried out within and without an accessory cell by the air space of accessory cell opening, and self-ignition combustion stabilized in separation of gaseous mixture, controlling NOx as a more positive thing can be realized.
[0015] By injecting a fuel from the injection valve prepared in the center of cylinder head abbreviation, respectively in cylinder shaft orientations and the direction to which it points to the boa wall at the time near the top dead center according to invention of claim 6 The stable self-ignition combustion is realizable, making it two-layer to the enriched-mixture layer for jump spark ignition, and the thin mixed gaseous layer for self-ignition, becoming possible to separate in the layer which does not carry out flame propagation of these, and controlling NOx using the usual fuel injection valve.
[0016]
[Embodiment of the Invention] The gestalt of operation of this invention is explained based on a drawing below. Drawing 1 is the system chart of the compressed self-ignition type internal combustion engine (especially gasoline engine) which shows 1 operation gestalt of this invention. However, it is switchable in jump-spark-ignition combustion and compressed self-ignition combustion so that compressed self-ignition combustion may be performed in a predetermined service condition with this engine and jump-spark-ignition combustion may be performed in other service conditions.
[0017] drawing 1 -- setting -- 1 -- a cylinder and 2 -- the cylinder head and 3 -- a piston and 4 -- a combustion chamber and 5 -- a suction port and 6 -- an inlet valve and 7 -- an exhaust air port and 8 -- an exhaust valve and 9 -- gaseous mixture -- an injection valve and 10 are ignition plugs. gaseous mixture -- an injection valve 9 -- the interior -- gaseous mixture -- the high-pressure air and the high-pressure fuel which the room is formed and are supplied from the outside -- this gaseous mixture -- it is the injection valve which is mixed indoors and injects the obtained gaseous mixture into a combustion chamber 4. moreover, gaseous mixture -- without it supplies a fuel to a room -- gaseous mixture -- only high-pressure air can also be injected now into a combustion chamber 4 by making an injection valve 9 open.
[0018] here -- gaseous mixture -- attaching an ignition plug 10 in the cylinder head 2 aslant, and making the point project in a combustion chamber 4, while attaching an injection valve 9 at right angles to the center section of the cylinder head 2 and making the nozzle hole face in a combustion chamber 4 -- it is -- gaseous mixture -- the fuel spray (spraying cone) formed of an injection valve 9 is approached, and the spark gap of an ignition plug 10 is arranged.
[0019] The electronic control (henceforth ECU) 20 which controls this engine is equipped with the combustion gestalt decision section 21 which judges whether it operates according to a service condition with which combustion gestalt of jump-spark-ignition combustion and compressed self-ignition combustion, the jump-spark-ignition combustion control section 22 which controls the combustion control parameter at the time of jump-spark-ignition combustion operation, and the compressed-self-ignition combustion control section 23 which controls the combustion control parameter at the time of compressed self-ignition combustion operation.
[0020] In addition, although the combustion gestalt decision section 21, the jump-spark-ignition combustion control section 22, and the compressed self-ignition combustion control section 23 can also be constituted from a hard-wired logical circuit, they are realized as a program of a microcomputer with this operation gestalt. Compressed self-ignition combustion is performed in a low middle turn and a low Naka load field as shown in the basis of such a configuration, and drawing 2 , and jump-spark-ignition combustion is performed in high rotation or a heavy load field.
[0021] Next, the property of compressed self-ignition combustion is explained. Drawing 3 shows the range where self-ignition combustion of the ignition stage to the same load is materialized. If the ignition stage is carried out at an early stage, knock reinforcement will increase and a knock

limitation will be exceeded. On the contrary, if the ignition stage is delayed, stability will get worse and a stability limitation will be exceeded. Therefore, the tolerance (range within a knock limitation and a stability limitation) of the ignition stage to be the formation range of compressed self-ignition combustion is very narrow range.

[0022] Drawing 4 shows the cylinder internal pressure at the time of changing an ignition stage, and the wave of heat release. The wave of a broken line is a wave at the time of carrying out the tooth lead angle of the ignition stage, and considering as immediately after a compression top dead center, and the wave of a continuous line is a wave at the time of carrying out the lag of the ignition stage from a compression top dead center. If the tooth lead angle of the ignition stage is carried out so that it may understand from now on, change of cylinder internal pressure will become steep. During compressed self-ignition combustion, if an ignition stage carries out a tooth lead angle from the optimal stage under a certain effect, change of cylinder internal pressure will become steep as above-mentioned, and also whenever [ cylinder internal temperature ] will go up in connection with this. This effect is carried into degree cycle in the form of the rise of the residual-gas temperature in a cylinder, and serves as an inclination in which the ignition stage of degree cycle carries out a tooth lead angle further. If an ignition stage carries out a lag from the optimal stage on the contrary, the ignition stage of degree cycle will serve as an inclination which carries out a lag further.

[0023] Thus, since the ignition stage in compressed self-ignition combustion is very unstable, it is necessary to control an ignition stage compulsorily, and this is burned by flame propagation and it is made for high concentration gaseous mixture and thin gaseous mixture to be formed in a combustion chamber, to carry out jump spark ignition to high concentration gaseous mixture, and to carry out self-ignition of the thin gaseous mixture by the rise of the cylinder internal pressure and temperature accompanying this combustion in this invention. According to this approach, it is possible to control a self-ignition stage by controlling a jump-spark-ignition stage certainly.

[0024] However, since the amount of NOx generation will increase from the case where self-ignition combustion of all the fuels is carried out, by this approach, it is desirable to make into necessary minimum the amount of the fuel contributed to flame propagation combustion (henceforth jump-spark-ignition combustion) of jump spark ignition and after that. Then, he is trying to prevent certainly that the amount of the fuel contributed to jump-spark-ignition combustion turns into more than the amount of setup in this invention by carrying out separation formation of high concentration gaseous mixture and the thin gaseous mixture by the combustion chamber.

[0025] Next, the flow of drawing 5 explains a control flow. By S1, engine-speed N and Load T are detected first. Next, a combustion gestalt is judged by S2. That is, it judges whether engine-speed N and the detection value of Load T are in the jump-spark-ignition combustion zone of the map of drawing 2 , or it is in a compressed self-ignition combustion zone.

[0026] Consequently, when jump-spark-ignition combustion is controlled by S3 when judged as the inside of a jump-spark-ignition combustion zone, and judged as a compressed self-ignition combustion zone, compressed self-ignition combustion is controlled by S4. the jump-spark-ignition combustion control performed by S3 -- like an inhalation-of-air line -- inside -- gaseous mixture -- an injection valve 9 is driven, injection supply of the gaseous mixture is carried out into a combustion chamber 4, an ignition plug 10 is driven at a compression stroke anaphase, and jump spark ignition is performed. In this case, the flame produced by jump spark ignition is spread to the gaseous mixture of the combustion chamber 4 whole.

[0027] the gaseous mixture for carrying out separation formation of high concentration gaseous mixture and the thin gaseous mixture by the combustion chamber, while performing control (for example, control an exhaust air line closes [ control ] an exhaust valve 8 to inside, and makes [ control ] the amount of residual gas increase [ control ] to it) which raises the temperature of inhalation air in the compressed self-ignition combustion control performed by S4, in order to satisfy the conditions of self-ignition -- an injection valve 9 is controlled. specifically, it is shown in drawing 6 -- as -- gaseous mixture -- an injection valve 9 -- like an inhalation-of-air line -- from -- the between in the first half of a compression stroke -- the 1st gaseous mixture -- injection -- performing -- after that and a compression stroke -- injection of only high-pressure air -- performing -- the 2nd [ further ] gaseous mixture -- injection is performed.

[0028] the 1st gaseous mixture -- the gaseous mixture by injection is mixed with the air in a

combustion chamber 4, and dilutes, and thin gaseous mixture is formed throughout a combustion chamber 4 (refer to drawing 6 (a)). a subsequent air injection -- gaseous mixture -- the 2nd gaseous mixture which the field of only air is formed in the perimeter of an injection valve 9 (refer to drawing 6 (b)), and is performed continuously -- injection -- gaseous mixture -- high concentration gaseous mixture is formed in the perimeter of an injection valve 9 (refer to drawing 6 (c)).

[0029] the 2nd gaseous mixture -- since injection is performed under the second half of a compression stroke, i.e., high back pressure, -- injection -- the range of gaseous mixture is short, and since ignition by the ignition plug 10 is performed while diffusion seldom progresses, the fuel concentration of this gaseous mixture becomes comparatively high. as a result -- gaseous mixture -- the perimeter of an injection valve 9 -- high concentration -- while gaseous mixture exists and a lean mixture exists in a periphery -- two gaseous mixture -- the gaseous mixture to which an air space exists between fields -- distribution (refer to drawing 7 ) is realizable. in addition -- drawing 7 -- high concentration -- gaseous mixture -- it is described as the field which does not carry out a spark ignition field for a field, and does not carry out flame propagation of a compression ignition field and the air space between these for a lean-mixture field.

[0030] such gaseous mixture -- distribution -- forming -- gaseous mixture -- if the ignition drive of the ignition plug 10 which adjoins an injection valve 9 is carried out -- high concentration -- gaseous mixture burns by flame propagation and a lean mixture burns by self-ignition in response to the rise of the cylinder internal pressure and temperature accompanying this combustion. this time -- high concentration -- since the air space dissociates spatially, gaseous mixture and a lean mixture can separate jump-spark-ignition combustion and self-ignition combustion, as shown in drawing 8 . For this reason, it can prevent that the amount of the fuel which carries out jump-spark-ignition combustion increases more than the amount of setup too much, and becomes excessive [ the amount of NOx generation ].

[0031] In addition, the lap as shown in drawing 9 in time may be produced that separation with jump-spark-ignition combustion and self-ignition combustion should just be performed spatially. Drawing 8 and drawing 9 show a heat release pattern, and dQ/dtheta is a heat rate. moreover, high concentration -- the layer to which the air space which separates gaseous mixture and a lean mixture changes only from air -- it is not necessary to be -- high concentration, so that the propagation flame of gaseous mixture is not made to spread to a lean mixture -- a fuel -- what is necessary is just a thin layer

[0032] furthermore, high concentration -- distribution as forming on a concentric circle is not indispensable, either, as shown in drawing 7 , and shows gaseous mixture (spark ignition field), a lean mixture (compression ignition field), and an air space (field which does not carry out flame propagation) to drawing 10 and drawing 11 -- high concentration -- separation formation of gaseous mixture (spark ignition field) and the lean mixture (compression ignition field) may be carried out. drawing 10 and the operation gestalt of drawing 11 -- the periphery of the cylinder head 2 -- gaseous mixture -- an injection valve 9 is attached aslant, this is approached, and the ignition plug 10 is arranged.

[0033] high concentration -- the accessory cell which opens for free passage and carries out opening to a combustion chamber (main combustion chamber) when separation with gaseous mixture and a lean mixture needs to be ensured -- preparing -- the inside of this accessory cell -- gaseous mixture -- an injection valve and an ignition plug -- arranging -- the above gaseous mixture -- it is good to control an injection valve. in this case, the 1st gaseous mixture -- the 2nd gaseous mixture which forms an air space near accessory cell opening while once scavenging the gaseous mixture in an accessory cell, and is performed after that by the air injection performed after injection -- injection -- the inside of an accessory cell -- high concentration -- separation of gaseous mixture can be ensured by forming gaseous mixture.

[0034] Other operation gestalten of this invention are further shown in drawing 12 and drawing 13 . In the system of drawing 12 , using a fuel injection valve 15, this is attached at right angles to the center section of the cylinder head 2, this is approached, and the ignition plug 10 is arranged. In this case, the fuel injection valve 15 is equipped with 2nd nozzle-hole 15b which injects a fuel in the direction (horizontally near direction) to which it points to 1st nozzle-hole 15a which injects a fuel to cylinder shaft orientations, and the boa wall at the time near the top dead center, as shown in drawing

13 .

[0035] The fuel injected by cylinder shaft orientations in this configuration by injecting a fuel in a compression stroke from a fuel injection valve 15 is that an enriched-mixture layer is formed without being spread and a thin mixed gaseous layer is formed with the fuel which it is injected in the direction of a boa wall, and is diffused, and the mixed temper cloth shown in 7 embodies, and it becomes possible to realize the heat-release pattern shown in drawing 8 or drawing 9 .

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] The system chart of the internal combustion engine which shows 1 operation gestalt of this invention
[Drawing 2] Drawing showing a compressed self-ignition combustion zone
[Drawing 3] Drawing showing the formation range of compressed self-ignition combustion
[Drawing 4] Drawing showing the cylinder internal pressure at the time of changing an ignition stage, and the wave of heat release
[Drawing 5] The flow chart which shows a control flow
[Drawing 6] the gaseous mixture at the time of compressed self-ignition combustion -- drawing showing the separation formation approach
[Drawing 7] Drawing showing the mixing temper cloth in a cylinder
[Drawing 8] Drawing showing an example of a heat release pattern
[Drawing 9] Drawing showing other examples of a heat release pattern
[Drawing 10] The system chart of the internal combustion engine which shows other operation gestalten of this invention
[Drawing 11] Drawing showing the mixing temper cloth in a cylinder in the real applied configuration of drawing 10
[Drawing 12] The system chart of the internal combustion engine which shows other operation gestalten of this invention
[Drawing 13] The enlarged drawing of the fuel injection valve nozzle-hole part in the operation gestalt of drawing 12
[Description of Notations]
1 Cylinder
2 Cylinder Head
3 Piston
4 Combustion Chamber
5 Suction Port
6 Inlet Valve
7 Exhaust Air Port
8 Exhaust Valve
9 Gaseous Mixture -- Injection Valve
10 Ignition Plug
15 Fuel Injection Valve
15a The 1st nozzle hole
15b The 2nd nozzle hole
20 ECU
21 Combustion Gestalt Decision Section
22 Jump-Spark-Ignition Combustion Control Section
23 Compressed Self-ignition Combustion Control Section

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* NOTICES *



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DRAWINGS

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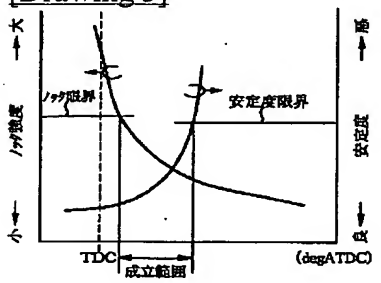
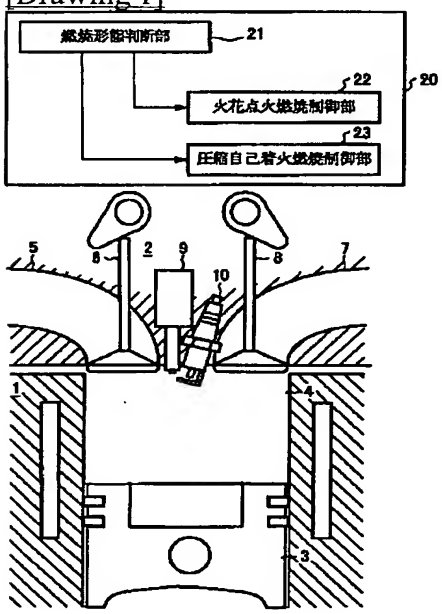
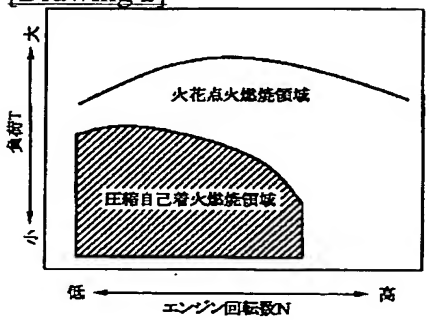
[Drawing 3]




[Drawing 1]




[Drawing 2]



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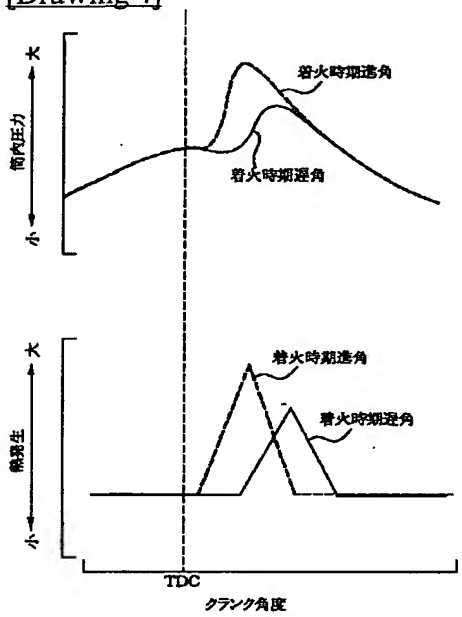


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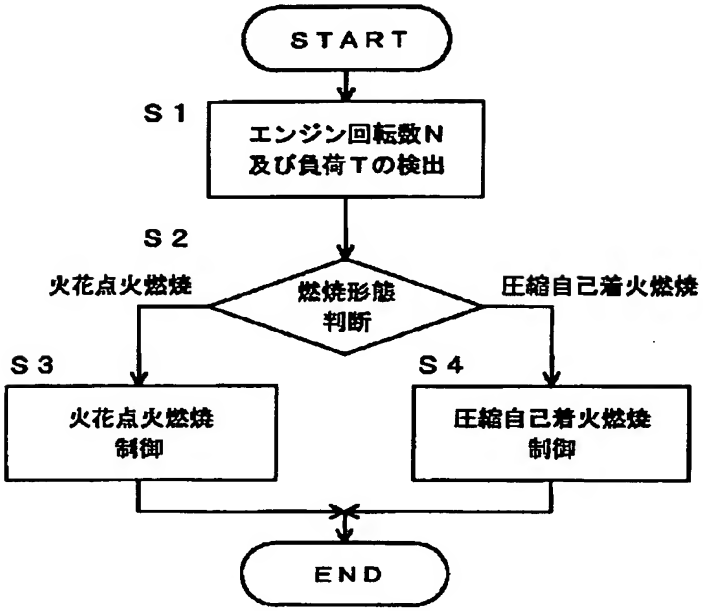
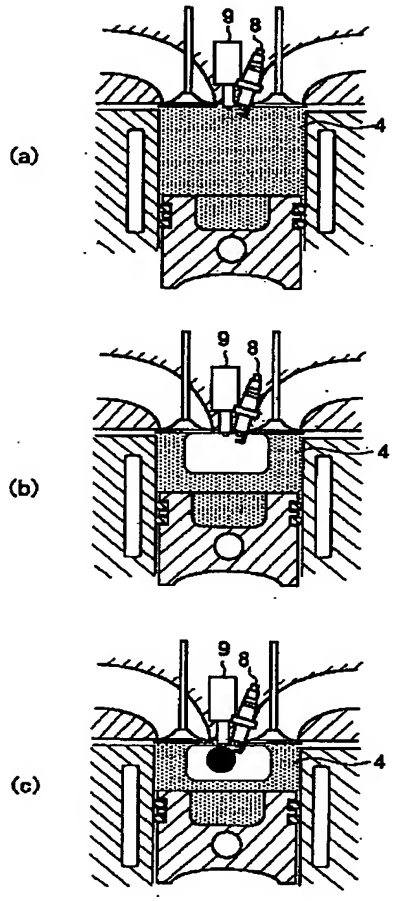
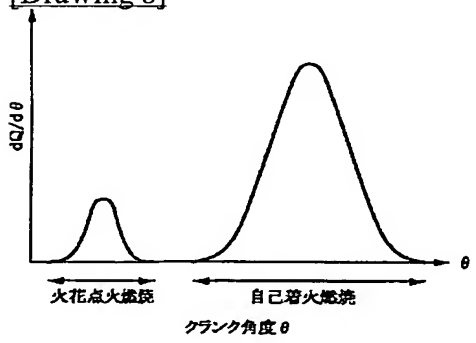

START
S 1
エンジン回転数N
及び負荷Tの検出
S 2
火花点火燃焼
燃焼形態
判断
圧縮自己着火燃焼
S 3
火花点火燃焼
制御
S 4
圧縮自己着火燃焼
制御
END

[Drawing 6]

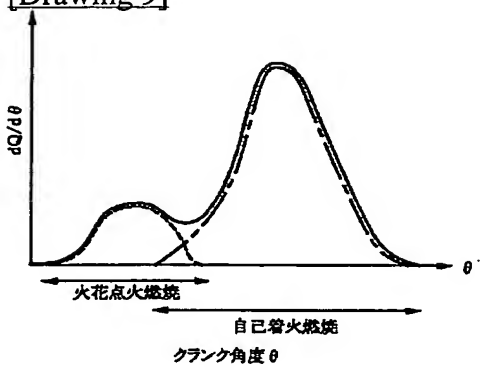



[Drawing 7]

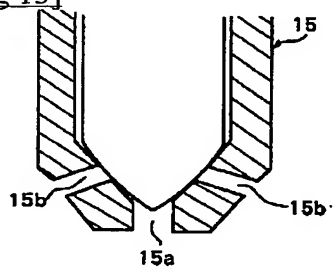

[Drawing 8]



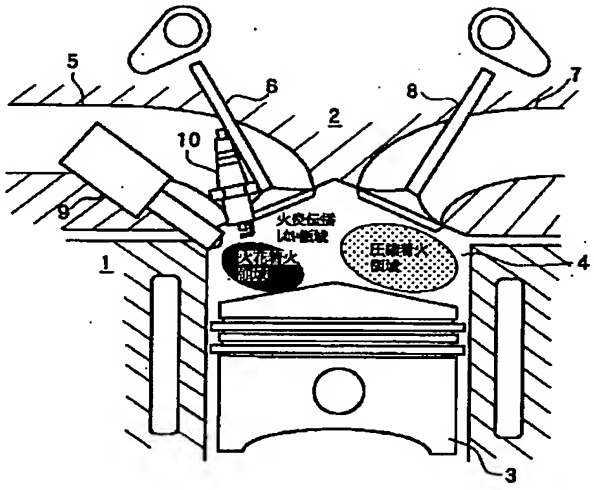
[Drawing 9]



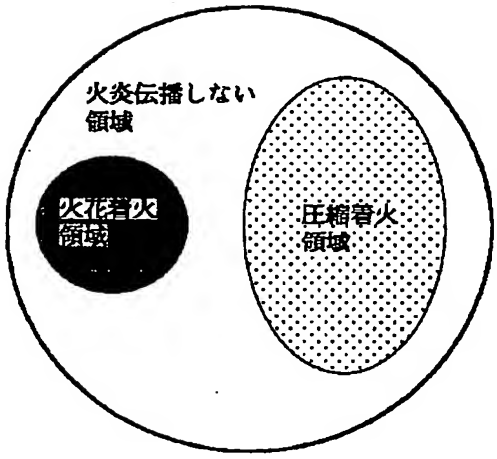

[Drawing 13]



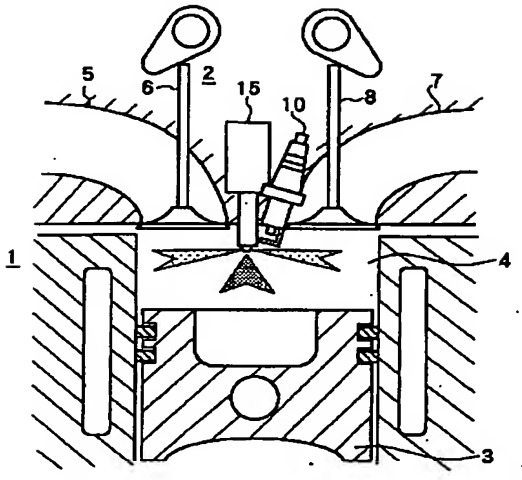

[Drawing 10]




[Drawing 11]




[Drawing 12]

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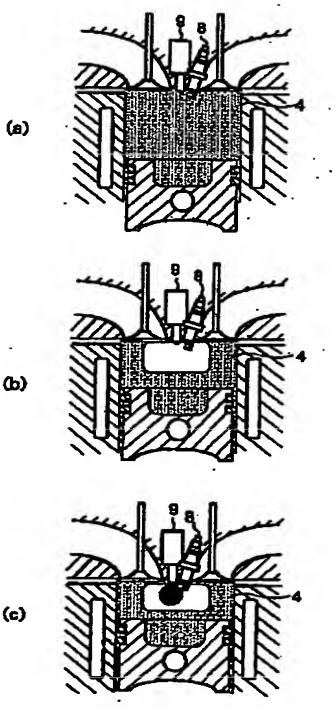
(54)【発明の名称】圧縮自己着火式内燃機関

(57)【要約】
【課題】　筒内の混合気分布を圧縮自己着火燃焼のために最適化することにより、安定した着火時期の制御を可能とすると共に、ＮＯｘ生成量を一定値以下に抑制する。
【解決手段】　混合気噴射弁９を用い、吸気行程などにおいて１回目の混合気噴射を行い、燃焼室４内に希薄混合気層を形成する。その後、圧縮行程において空気のみを噴射し、火炎伝播しない空気層を形成する。これに続いて２回目の混合気噴射を行い、高背圧下で高濃度混合気層を形成し、点火プラグ１０によりこれに火花点火する。この火花点火燃焼による圧力と温度の上昇で希薄混合気層を自己着火させる。



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【特許請求の範囲】

【請求項１】筒内に直接燃料を噴射する噴射弁を具備し、少なくとも所定の運転条件にて圧縮自己着火燃焼を行わせる圧縮自己着火式内燃機関において、

筒内混合気場を濃い混合気領域と薄い混合気領域とに分け、濃い混合気と薄い混合気との間を火炎伝播しない層にしたことを特徴とする圧縮自己着火式内燃機関。

【請求項２】筒内中心に濃い混合気を配し、その周りを取り囲むように火炎伝播しないほどの薄い混合気を配し、その周りに前記濃い混合気が燃焼することにより自己着火に至る薄い混合気を配したことを特徴とする請求項１記載の圧縮自己着火式内燃機関。

【請求項３】筒内中央から偏心した位置に濃い混合気を配し、この濃い混合気と交わらない位置に濃い混合気が燃焼することによって自己着火に至る薄い混合気を配し、前記濃い混合気と前記薄い混合気とを火炎伝播しない層にて隔てたことを特徴とする請求項１記載の圧縮自己着火式内燃機関。

【請求項４】筒内に直接燃料及び空気を噴射可能な噴射弁を用いて、燃料噴射を２回に分割して行い、１回目の燃料噴射と２回目の燃料噴射との間に空気のみを噴射することを特徴とする請求項１～請求項３のいずれか１つに記載の圧縮自己着火式内燃機関。

【請求項５】燃焼室に開口する副室を具備し、この副室に直接燃料及び空気を噴射可能な噴射弁を用いて、燃料噴射を２回に分割して行い、１回目の燃料噴射と２回目の燃料噴射との間に空気のみを噴射することを特徴とする請求項１～請求項３のいずれか１つに記載の圧縮自己着火式内燃機関。

【請求項６】前記噴射弁をシリンダヘッド略中央に設ける一方、シリンダ軸方向と、上死点近傍時のボア壁へ指向する方向とに、それぞれ燃料を噴射する複数の噴口を持たせたことを特徴とする請求項１～請求項３のいずれか１つに記載の圧縮自己着火式内燃機関。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、少なくとも所定の運転条件にて圧縮自己着火燃焼を行わせる圧縮自己着火式内燃機関に関する。

【０００２】

【従来の技術】圧縮自己着火式内燃機関の一例として、特開平１０－１９６４２４号公報に記載されているものがある。これは、シリンダ内のピストンとは別に補助圧縮手段としてコントロールピストンを備えており、自己着火寸前の高温に至るまで圧縮された混合気に対し、コントロールピストンによる圧縮を更に加えることで、混合気を一斉に自己着火させる構成となっている。

【０００３】また、点火プラグを備える圧縮自己着火式内燃機関が、特開平１１－２１０５３９号公報に開示されている。これは、圧縮行程末期における筒内のガス温度が、点火すると混合気全体の自己着火を引き起こす目標温度であるかを判断し、吸気弁の開弁時期を制御することにより、圧縮行程末期における筒内のガス温度が目標温度に維持されるように制御している。

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【０００４】

【発明が解決しようとする課題】上記２つの従来技術は、いずれも自己着火燃焼の着火時期を強制的に制御しようとするものであるが、コントロールピストンを用いる特開平１０－１９６４２４号公報の技術は、エンジンの構造が複雑になり過ぎて実用化が困難である。一方、火花点火を用いる特開平１１－２１０５３９号公報の技術では、火花点火によって与えることができる補助的な圧力上昇の幅が小さく、安定した着火時期制御を行うことが困難である。

【０００５】火花点火による圧力上昇幅を大きくする方法としては、燃焼室内の一部に燃料濃度の高い領域を形成し、この領域の混合気に火花点火して限られた領域の燃料を火炎伝播燃焼させることが考えられるが、燃焼室内の状況が様々に変化すると火炎伝播燃焼する領域の範囲も様々に変化してしまい、火炎伝播燃焼に伴って多く発生するＮＯｘの生成量を一定量以下に抑制することが困難となる。

【０００６】そこで、本発明は、混合気場形成に着目し、筒内の混合気分布を圧縮自己着火式内燃機関のために最適化することにより、安定した着火時期の制御を可能とすると共に、ＮＯｘ生成量を一定値以下に抑制することを目的とする。

【０００７】

【課題を解決するための手段】このため、請求項１の発明では、筒内に直接燃料を噴射する噴射弁を具備し、少なくとも所定の運転条件にて圧縮自己着火燃焼を行わせる圧縮自己着火式内燃機関において、筒内混合気場を濃い混合気領域と薄い混合気領域とに分け、濃い混合気と薄い混合気との間を火炎伝播しない層にしたことを特徴とする。

【０００８】請求項２の発明では、筒内中心に濃い混合気を配し、その周りを取り囲むように火炎伝播しないほどの薄い混合気を配し、その周りに前記濃い混合気が燃焼することにより自己着火に至る薄い混合気を配したことを特徴とする。請求項３の発明では、筒内中央から偏心した位置に濃い混合気を配し、この濃い混合気と交わらない位置に濃い混合気が燃焼することによって自己着火に至る薄い混合気を配し、前記濃い混合気と前記薄い混合気とを火炎伝播しない層にて隔てたことを特徴とする。

【０００９】請求項４の発明では、筒内に直接燃料及び空気を噴射可能な噴射弁を用いて、燃料噴射を２回に分割して行い、１回目の燃料噴射と２回目の燃料噴射との間に空気のみを噴射することを特徴とする。請求項５の発明では、燃焼室に開口する副室を具備し、この副室に

直接燃料及び空気を噴射可能な噴射弁を用いて、燃料噴射を２回に分割して行い、１回目の燃料噴射と２回目の燃料噴射との間に空気のみを噴射することを特徴とする。

【００１０】請求項６の発明では、前記噴射弁をシリンダヘッド略中央に設ける一方、シリンダ軸方向と、上死点近傍時のボア壁へ指向する方向とに、それぞれ燃料を噴射する複数の噴口を持たせたことを特徴とする。

【００１１】

【発明の効果】請求項１の発明によれば、筒内混合気場を濃い混合気領域と薄い混合気領域とに２層化し、濃い混合気層と薄い混合気層とを火炎伝播しない層にて隔てることにより、濃い混合気層の火花点火による火炎が薄い混合気層に伝播せず、濃い混合気層の燃焼による圧力と温度の上昇で薄い混合気層が自己着火するため、火花点火時期を制御することで自己着火時期を確実に制御することができる一方、火炎伝播燃焼に寄与する燃料の量が設定量以上となるのを確実に防止して、ＮＯｘの生成を抑制することができる。

【００１２】請求項２の発明によれば、筒内中心に濃い混合気を配し、筒内中心から外側の比較的温度が低い領域に自己着火する薄い混合気を配することにより、急峻な燃焼を抑制することが可能となり、圧縮自己着火燃焼領域を高負荷側に広げることが可能となる他、筒内中心にて濃い混合気を燃焼させるため、未燃混合気を抑制し、ＨＣ排出量を低減することが可能となる。

【００１３】請求項３の発明によれば、筒内中央から偏心した位置に濃い混合気を配することにより、濃い混合気が筒内中心から偏心した位置にて発熱することにより筒内温度分布に斑が生じることで、急峻な燃焼を抑制することが可能となり、圧縮自己着火燃焼領域を高負荷側に広げることが可能となる。請求項４の発明によれば、筒内に直接燃料及び空気を噴射可能な噴射弁を用いて、燃料噴射を２回に分割して行い、１回目の燃料噴射と２回目の燃料噴射との間に空気のみを噴射することにより、１回目の燃料噴射による燃料は燃焼室内の空気と混ざり合って希薄化し、その後の空気噴射により、空気のみの領域が形成され、続けて行われる２回目の燃料噴射により、高背圧下で高濃度な混合気が形成される。これにより、火花点火のための濃い混合気と、自己着火のための薄い混合気とを、空気層により、火炎伝播しないよう確実に隔てることができ、ＮＯｘを抑制しつつ、安定した自己着火燃焼を実現できる。

【００１４】請求項５の発明によれば、燃焼室に連通する副室を具備し、この副室に直接燃料及び空気を噴射可能な噴射弁を用いて、燃料噴射を２回に分割して行い、１回目の燃料噴射と２回目の燃料噴射との間に空気のみを噴射することにより、１回目の燃料噴射による燃料はその後の空気噴射により副室から確実に掃気されて燃焼室内の空気と混ざり合って希薄化し、２回目の燃料噴射による燃料はその前に噴射された空気が副室開口部を塞ぐことで副室内に濃い混合気を形成することができる。これにより、火花点火のための濃い混合気と、自己着火のための薄い混合気とを、副室開口部の空気層により、副室の内外に、火炎伝播しないよう確実に隔てることができ、混合気の分離をより確実なものとして、ＮＯｘを抑制しつつ、安定した自己着火燃焼を実現できる。

【００１５】請求項６の発明によれば、シリンダヘッド略中央に設けた噴射弁より、シリンダ軸方向と、上死点近傍時のボア壁へ指向する方向とに、それぞれ燃料を噴射することで、火花点火のための濃い混合気層と自己着火のための薄い混合気層とに２層化し、これらを火炎伝播しない層にて隔てることが可能となり、通常の燃料噴射弁を用いて、ＮＯｘを抑制しつつ、安定した自己着火燃焼を実現できる。

【００１６】

【発明の実施の形態】以下に本発明の実施の形態を図面に基づいて説明する。図１は本発明の一実施形態を示す圧縮自己着火式内燃機関（特にガソリンエンジン）のシステム図である。但し、このエンジンでは、所定の運転条件において圧縮自己着火燃焼を行い、他の運転条件では火花点火燃焼を行うよう、火花点火燃焼と圧縮自己着火燃焼とを切換可能となっている。

【００１７】図１において、１はシリンダ、２はシリンダヘッド、３はピストン、４は燃焼室、５は吸気ポート、６は吸気弁、７は排気ポート、８は排気弁、９は混合気噴射弁、１０は点火プラグである。混合気噴射弁９は、内部に混合気室が形成されており、外部から供給される高圧の空気と燃料とをこの混合気室内で混合し、得られた混合気を燃焼室４内へ噴射する噴射弁である。また、混合気室へ燃料を供給することなく混合気噴射弁９を開弁させることにより、高圧空気のみを燃焼室４内へ噴射することもできるようになっている。

【００１８】ここで、混合気噴射弁９はシリンダヘッド２の中央部に垂直に取付けて、その噴口を燃焼室４内に臨ませる一方、点火プラグ１０はシリンダヘッド２に斜めに取付けて、その先端部を燃焼室４内に突出させることで、混合気噴射弁９により形成される燃料噴霧（噴霧円錐）に近接して点火プラグ１０のスパークギャップを配置してある。

【００１９】このエンジンを制御する電子制御装置（以下、ＥＣＵという）２０は、運転条件に応じて火花点火燃焼と圧縮自己着火燃焼とのいずれの燃焼形態で運転を行うかを判断する燃焼形態判断部２１と、火花点火燃焼運転時の燃焼制御パラメータを制御する火花点火燃焼制御部２２と、圧縮自己着火燃焼運転時の燃焼制御パラメータを制御する圧縮自己着火燃焼制御部２３とを備えている。

【００２０】尚、燃焼形態判断部２１、火花点火燃焼制御部２２及び圧縮自己着火燃焼制御部２３は、ハードワ

イヤードの論理回路で構成することもできるが、本実施形態ではマイクロコンピュータのプログラムとして実現されている。このような構成のもと、図２に示すような、低中回転及び低中負荷領域において圧縮自己着火燃焼を行い、高回転又は高負荷領域において火花点火燃焼を行う。

【００２１】次に、圧縮自己着火燃焼の特性について説明する。図３は、同一負荷に対する着火時期の自己着火燃焼が成立する範囲を示すものである。着火時期を早期にしていくとノック強度が増大して、ノック限界を超える。逆に、着火時期を遅らしていくと安定度が悪化して、安定度限界を超える。従って、圧縮自己着火燃焼の成立範囲である着火時期の許容範囲（ノック限界内かつ安定度限界内の範囲）は、極めて狭い範囲である。

【００２２】図４は、着火時期を変化させた場合の筒内圧力及び熱発生の波形を示すものである。破線の波形は着火時期を進角して圧縮上死点直後とした場合の波形であり、実線の波形は着火時期を圧縮上死点から遅角した場合の波形である。これからわかるように、着火時期を進角すると、筒内圧力の変化は急峻となる。圧縮自己着火燃焼中に、何らかの影響で着火時期が最適な時期から進角すると、上記の通り筒内圧力の変化が急峻となり、これに伴って筒内温度も上昇する。この影響は筒内残留ガス温度の上昇という形で次サイクルへ持ち込まれ、次サイクルの着火時期が更に進角する傾向となる。反対に、着火時期が最適な時期から遅角すると、次サイクルの着火時期は更に遅角する傾向となる。

【００２３】このように、圧縮自己着火燃焼における着火時期は非常に不安定であるため、強制的に着火時期を制御してやる必要があり、本発明では、燃焼室内に高濃度な混合気と希薄な混合気とを形成し、高濃度な混合気に火花点火してこれを火炎伝播によって燃焼させ、この燃焼に伴う筒内圧力と温度の上昇によって希薄な混合気を自己着火させるようにしている。この方法によれば、火花点火時期を制御することで自己着火時期を確実に制御することが可能である。

【００２４】但し、この方法では、全ての燃料を自己着火燃焼させる場合よりもＮＯｘ生成量が増加することになるので、火花点火とその後の火炎伝播燃焼（以下、火花点火燃焼という）に寄与する燃料の量を必要最小限とすることが望ましい。そこで本発明では、高濃度な混合気と希薄な混合気とを燃焼室内で分離形成することにより、火花点火燃焼に寄与する燃料の量が設定量以上となることを確実に防止するようにしている。

【００２５】次に、図５のフローにて制御の流れを説明する。先ずＳ１で、エンジン回転数Ｎ及び負荷Ｔを検出する。次にＳ２で、燃焼形態を判断する。すなわち、エンジン回転数Ｎ及び負荷Ｔの検出値が図２のマップの火花点火燃焼領域内にあるか、圧縮自己着火燃焼領域内にあるかを判断する。

【００２６】この結果、火花点火燃焼領域内と判断された場合には、Ｓ３で火花点火燃焼の制御を行い、圧縮自己着火燃焼領域と判断された場合には、Ｓ４で圧縮自己着火燃焼の制御を行う。Ｓ３で行われる火花点火燃焼制御では、吸気行程中に混合気噴射弁９を駆動して燃焼室４内に混合気を噴射供給し、圧縮行程後期に点火プラグ１０を駆動して火花点火を行う。この場合、火花点火によって生じた火炎は燃焼室４全体の混合気に伝播する。

【００２７】Ｓ４で行われる圧縮自己着火燃焼制御では、自己着火の条件を成立させるために吸入空気の温度を上昇させる制御（例えば、排気行程中に排気弁８を閉じて残留ガス量を増加させる制御）を行うと共に、高濃度な混合気と希薄な混合気とを燃焼室内で分離形成するための混合気噴射弁９の制御を行う。具体的には、図６に示すように、混合気噴射弁９により、吸気行程から圧縮行程前期の間で１回目の混合気噴射を実行し、その後、圧縮行程にて、高圧空気のみの噴射を実行し、更に２回目の混合気噴射を実行する。

【００２８】１回目の混合気噴射による混合気は燃焼室４内の空気と混ざり合って希薄化し、燃焼室４の全域に希薄な混合気を形成する（図６（ａ）参照）。その後の空気噴射により、混合気噴射弁９の周囲に空気のみの領域が形成され（図６（ｂ）参照）、続けて実行される２回目の混合気噴射により、混合気噴射弁９の周囲に高濃度な混合気が形成される（図６（ｃ）参照））。

【００２９】２回目の混合気噴射は、圧縮行程の後半、すなわち高背圧下で実行されるため、噴射混合気の到達距離が短く、拡散があまり進まないうちに点火プラグ１０による点火が行われるので、この混合気の燃料濃度は比較的高くなる。結果として、混合気噴射弁９の周囲に高濃度混合気が存在し、周辺部に希薄混合気が存在すると共に、２つの混合気領域の間に空気層が存在する混合気分布（図７参照）を実現することができる。尚、図７では、高濃度混合気領域を火花着火領域、希薄混合気領域を圧縮着火領域、これらの間の空気層を火炎伝播しない領域と記してある。

【００３０】このような混合気分布を形成して混合気噴射弁９に隣接する点火プラグ１０を点火駆動すると、高濃度混合気が火炎伝播によって燃焼し、この燃焼に伴う筒内圧力と温度の上昇を受けて希薄混合気が自己着火によって燃焼する。このとき、高濃度混合気と希薄混合気とは空気層によって空間的に分離されているので、図８に示すように火花点火燃焼と自己着火燃焼とを分離することができる。このため、火花点火燃焼する燃料の量が設定量より多くなり過ぎてＮＯｘ生成量が過大となることを防止できる。

【００３１】尚、火花点火燃焼と自己着火燃焼との分離は空間的に行われていればよく、時間的には図９に示すような重なりを生じていてもよい。図８及び図９は熱発生パターンを示すもので、ｄＱ／ｄθは熱発生率であ

る。また、高濃度混合気と希薄混合気とを分離する空気層が空気のみから成る層である必要はなく、高濃度混合気の伝播火炎を希薄混合気へ伝播させないほど燃料希薄な層となっていればよい。

【００３２】更に、高濃度混合気（火花着火領域）と希薄混合気（圧縮着火領域）と空気層（火炎伝播しない領域）とを図７に示したように同心円上に形成することも必須ではなく、図１０及び図１１に示すような分布で高濃度混合気（火花着火領域）と希薄混合気（圧縮着火領域）とを分離形成してもよい。図１０及び図１１の実施形態では、シリンダヘッド２の周辺部に混合気噴射弁９を斜めに取付け、これに近接して点火プラグ１０を配置してある。

【００３３】高濃度混合気と希薄混合気との分離をより確実に行う必要がある場合は、燃焼室（主燃焼室）に連通して開口する副室を設け、この副室内に混合気噴射弁と点火プラグとを配設して、上記のような混合気噴射弁の制御を行うとよい。この場合、１回目の混合気噴射後に実行される空気噴射により、副室内の混合気を一旦掃気すると共に副室開口部付近に空気層を形成し、その後実行する２回目の混合気噴射により、副室内に高濃度混合気を形成することで、混合気の分離をより確実に行うことができる。

【００３４】図１２及び図１３には更に本発明の他の実施形態を示す。図１２のシステムでは、燃料噴射弁１５を用い、これをシリンダヘッド２の中央部に垂直に取付け、これに近接して点火プラグ１０を配置してある。この場合、燃料噴射弁１５は、図１３に示されるように、シリンダ軸方向に燃料を噴射する第１の噴口１５ａと、上死点近傍時のボア壁へ指向する方向（水平に近い方向）に燃料を噴射する第２の噴口１５ｂとを備えている。

【００３５】かかる構成において、燃料噴射弁１５から圧縮行程において燃料を噴射することにより、シリンダ軸方向に噴射された燃料は拡散せずに濃い混合気層が形成され、ボア壁方向へ噴射されて拡散する燃料により薄い混合気層が形成されることで、７に示す混合気分布を具現化し、図８又は図９に示す熱発生パターンを実現することが可能となる。

【図面の簡単な説明】

【図１】　本発明の一実施形態を示す内燃機関のシステム図

【図２】　圧縮自己着火燃焼領域を示す図

【図３】　圧縮自己着火燃焼の成立範囲を示す図

【図４】　着火時期を変化させた場合の筒内圧力及び熱発生の波形を示す図

【図５】　制御の流れを示すフローチャート

【図６】　圧縮自己着火燃焼時の混合気分離形成方法を示す図

【図７】　筒内混合気分布を示す図

【図８】　熱発生パターンの一例を示す図

【図９】　熱発生パターンの他の例を示す図

【図１０】　本発明の他の実施形態を示す内燃機関のシステム図

【図１１】　図１０の実施形態における筒内混合気分布を示す図

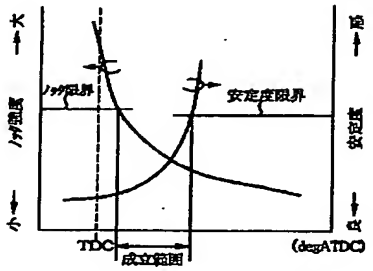
【図１２】　本発明の他の実施形態を示す内燃機関のシステム図

【図１３】　図１２の実施形態における燃料噴射弁噴口部分の拡大図

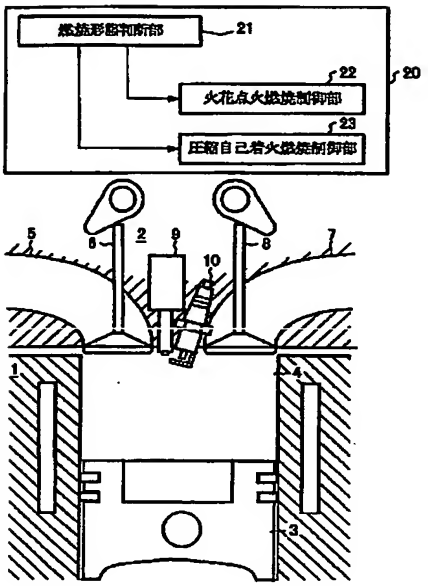
【符号の説明】

１　シリンダ
２　シリンダヘッド
３　ピストン
４　燃焼室
５　吸気ポート
６　吸気弁
７　排気ポート
８　排気弁
９　混合気噴射弁
１０　点火プラグ
１５　燃料噴射弁
１５ａ　第１の噴口
１５ｂ　第２の噴口
２０　ＥＣＵ
２１　燃焼形態判断部
２２　火花点火燃焼制御部
２３　圧縮自己着火燃焼制御部

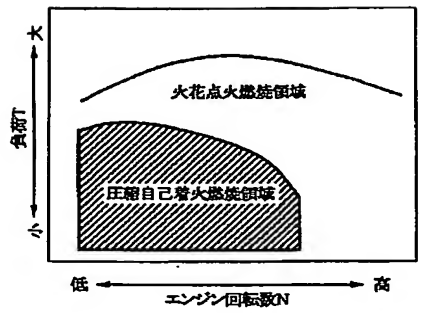
【図３】



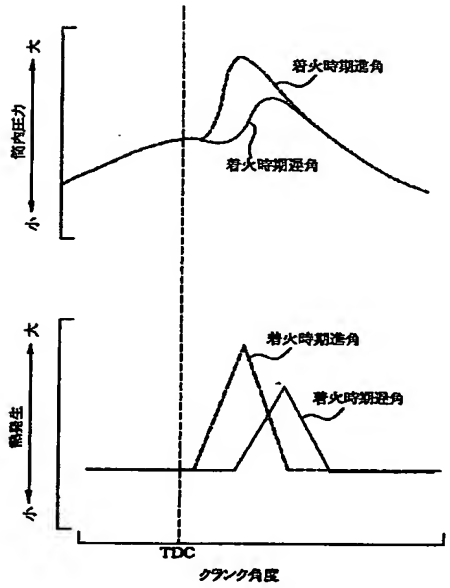
【図１】


燃焼形態判断部
21
22
火花点火燃焼制御部
23
圧縮自己着火燃焼制御部
20
5
6
2
9
10
8
7
1
4
3

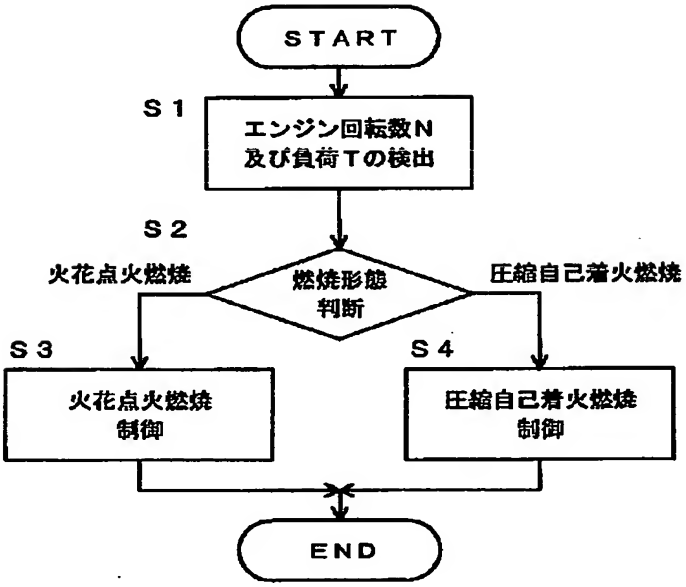
【図２】


大
負荷T
小
火花点火燃焼領域
圧縮自己着火燃焼領域
低
高
エンジン回転数N

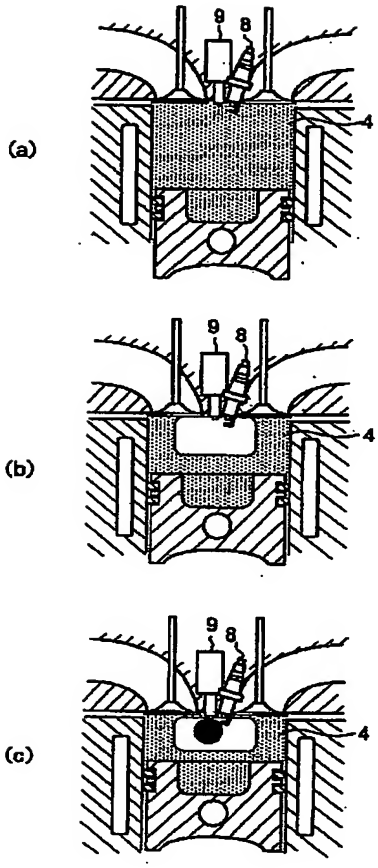
【図４】


大
筒内圧力
小
着火時期進角
着火時期遅角
大
機関発生
小
着火時期進角
着火時期遅角
TDC
クランク角度

【図５】

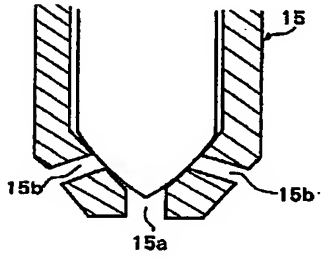

START
S１
エンジン回転数N
及び負荷Tの検出
S２
火花点火燃焼
燃焼形態
判断
圧縮自己着火燃焼
S３
S４
火花点火燃焼
制御
圧縮自己着火燃焼
制御
END

【図６】

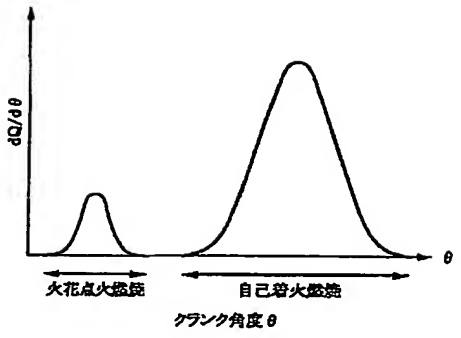



【図７】

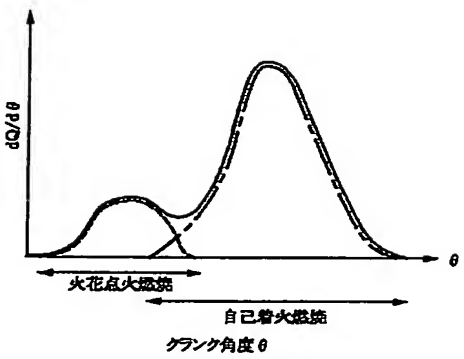

【図１３】



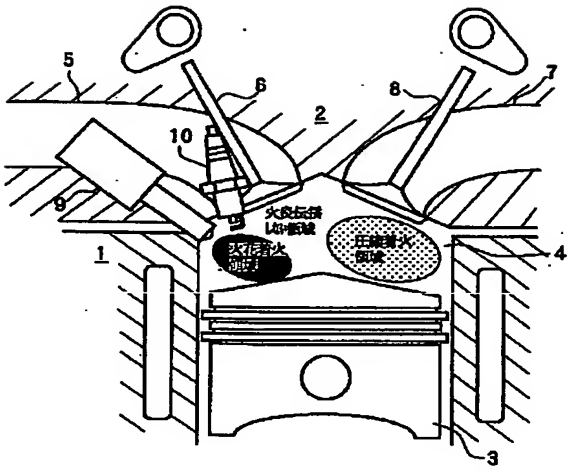

【図８】



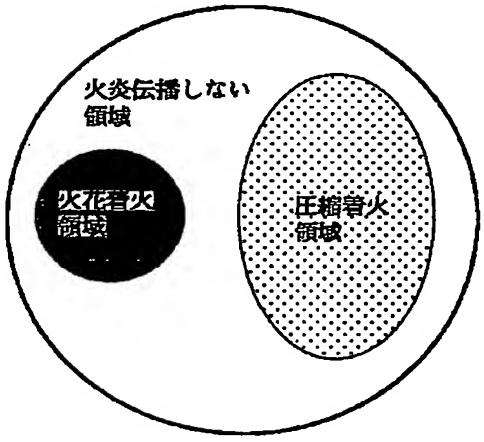

【図９】



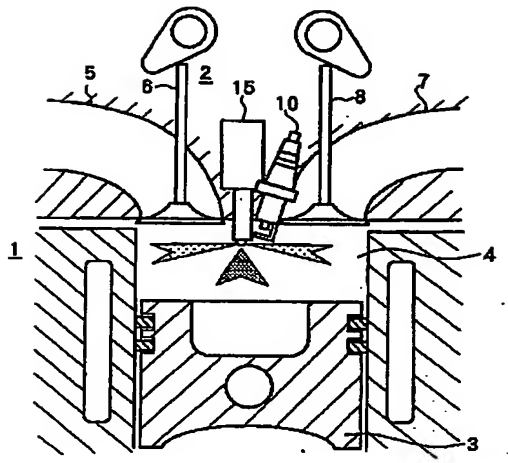
【図１０】




【図１１】



【図１２】

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